Comparison of Results from the MCNP Criticality Validation Suite Using ENDF/B-VI and Preliminary ENDF/B-VII Nuclear Data

Russell D. Mosteller

Los Alamos National Laboratory

[LA-UR-03-8855] The MCNP Criticality Validation Suite is a collection of 31 benchmarks taken from the International Handbook of Evaluated Criticality Benchmark Experiments. It includes cases with a variety of fuels, moderators, reflectors, spectra, and geometries. Specifically, it contains six cases with U-233 fuel, eight cases with highly enriched uranium (HEU), six cases with intermediate-enriched uranium (IEU), two cases with low-enriched uranium (LEU), and nine cases with plutonium. Except for LEU (which can reach criticality only with a thermal spectrum), there are cases with fast, intermediate, and thermal spectra for each of these fuels. The fast cases include bare spheres, cores with heavy reflectors, cores with light reflectors, and lattices. The thermal cases include lattices of fuel pins and solutions for each of the five types of fuel. The cases with intermediate spectra are less uniform, due to the limited number of experiments with such spectra.

Three sets of MCNP5 calculations were performed for the MCNP Criticality Validation Suite. The first set employed nuclear data from ENDF/B-VI Release 8, the final release for ENDF/B-VI. The second set employed preliminary ENDF/B-VII data generated by group T-16 at Los Alamos National Laboratory for the uranium isotopes and for plutonium-239 but retained ENDF/B-VI data for all other nuclides. The third set was the same as the second except that a new set of U-238 resonance parameters generated by researchers at Oak Ridge National Laboratory (ORNL) was added to the T-16 evaluation.

All cases were run with 250 generations of 5,000 neutrons each. Results from the first 50 generations of each case were omitted from the statistics. Consequently, the results from each case are based on a total of 1,000,000 active neutron histories.

The preliminary ENDF/B-VII data produce marked improvements in k-eff for bare spheres of U-233 (Jezebel-233), HEU (Godiva), and plutonium (Jezebel). Furthermore, the reactivity swings between those cases and the corresponding Flattop cases (which enclose the sphere inside an annulus of normal uranium) are substantially decreased. They also significantly improve k-eff for BIG TEN (IEU reflected by normal uranium) and for HEU and plutonium spheres immersed in water. In addition, inclusion of the ORNL resonance parameters for U-238 produces a significantly better value for k-eff for the lattice of LEU fuel pins in water.

At the same time, they produce worse results than ENDF/B-VI for thermal lattices of U-233 and HEU pins, for an IEU sphere reflected by graphite, and for a plutonium sphere reflected by thorium (THOR). Furthermore, k-eff for the uranium cases with intermediate spectra remains substantially underpredicted, while k-eff for the plutonium case with an intermediate spectrum (HISS/HPG) continues to be significantly overpredicted.

In conclusion, preliminary ENDF/B-VII evaluations for the uranium isotopes and Pu-239 appear to produce substantial improvements for certain cases with fast spectra and for lattices of LEU fuel pins in water. However, improvements still are needed in some areas, particularly those cases with intermediate spectra.

Email: mosteller@lanl.gov